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Depressurization Concerns

From the Editor . . .

The launch of a new Building Code update provides an opportunity to review one's knowledge and understanding of the revisions to regulations.

In my other life, one of my tasks is delivering builder workshops. I've had the opportunity to do a number in various BC communities over the past few months. These workshops provide an opportunity to discuss better building practices for durable, energy-efficient construction. It's a two-way discussion – I learn as much from seasoned builders as I am able to impart to them. Invariably one topic of discussion is codes and regulations applicable to homebuilding, which we all need to contend with.

Through initiatives such as R-2000 and Built-Green we are trying to get builders to build better, more energy efficient homes. We want to encourage much more energy efficient construction. We stress the importance of applying building science principles when evaluating new or alternate construction practices and details to avoid predictable problems. There is plenty of discussion of how sound building science principles are the basis of Canadian codes, and how they can accommodate a variety of construction details.

So it is disheartening to hear repeatedly from builders that what we are discussing makes sense, and that at some time they may have attempted to improve their construction practices, only to hit a brick wall – in the form of local regulators who often insist on sticking to old practices, irrespective of what makes common sense or even what the code allows. I'm often told "but my building inspector won't allow that".

I understand that regulators have challenges. On the one hand, local government lawyers and insurance brokers are telling them to avoid any risk for the local government. On the other hand, they insist on practices and details that don't make sense, in part because "it's the way that's always been done", in the belief that they won't get into trouble.

I understand there is a need for judicious review to be done when something different is being proposed. I understand that building inspectors see more than their share of questionable practices and details. But just because some do stupid things, it shouldn't automatically be a rationale for not considering alternatives when a builder or other professional proposes something a little different.

The building code is quite explicit that it allows alternative solutions provided that the intent is met. Yet it is surprising how closed minded some regulators seem to be. They will not readily consider equivalencies, or if they do (because they have to, as it is allowed for in the code), they make it difficult enough so that few are willing to press the issue. The result, unfortunately, is making it difficult to see an evolution and improvement of construction practices.

We can only hope that with the edition of the Building Code, and the way it has been restructured, building officials will also reconsider how the code is administered, and not put obstacles in the way of reasonable and appropriate construction practices that may differ from the "tried and true".

Richard Kadulski,
Editor

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Depressurization Concerns:
Don't Forget a House is a System

The way we build homes today is much different than was the case in the past. That is why builder training today stresses the importance of recognizing that a *house–is–a system*.

New building materials, new techniques, attention to draft proofing for energy conservation and building durability have resulted in homes that are more airtight than at any time in the past.

The trend for more draft-free construction has been encouraged by the R-2000 standard, which has become an international benchmark for high quality, energy efficient, healthy and environmentally superior homes. However, the trend to tighter construction predated the R-2000 program. Blower door testing has tracked the increasing airtightness of new construction over the years (see Fig 1). It has been a useful tool to help builders improve their construction practices and to understand where air leakage is occurring and how to prevent drafts, which has led to much tighter construction across the country.

At the same time as homes are being built more draft-free, they have more high capacity exhaust appliances, such as large kitchen exhaust fans, central vacuum cleaners that exhaust to the outdoors, dryers, and numerous bathroom fans. The net result of this is that the interior environment can at various times be placed under a significant negative pressure. Blower door tests can also measure the depressurization levels the house may be subjected to.

Depressurization presents health and safety concerns if combustion equipment is present because it could be subject to spillage of combustion gases, fuel odours, and ingress of soil gases. In regions where oil is used as a heating fuel, there are an increasing number of complaints about odours. These are happening because increasingly there is a greater awareness of environmental issues and indoor air quality concerns so that people are less tolerant when facing odours. This is made worse by increasing levels of depressurization.

The pressure balance in the house is not just an abstract issue of interest to academics and code authorities; it also represents a health and safety issue. We've raised the concern about poorly located flues and cold chimneys in the past. In extreme cases, it can directly affect the lives of occupants with devastating consequences if toxic levels of contaminants inside the house are generated. (Solplan Review No. 128, May 2006)

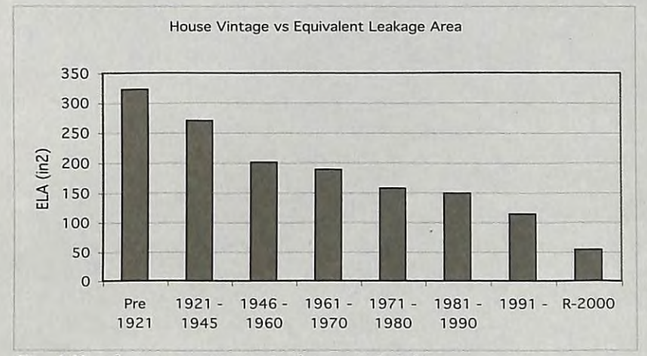
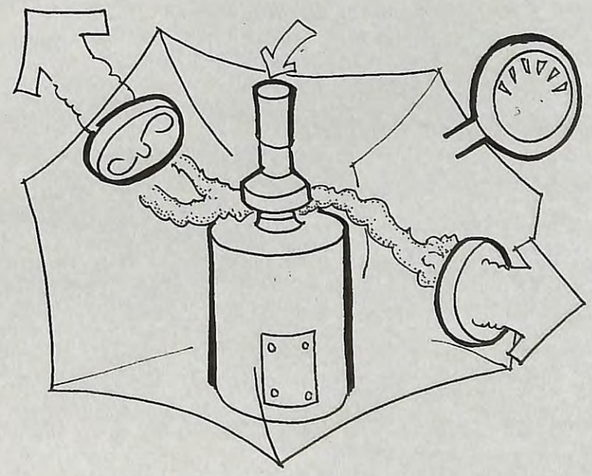


Fig. 1 New houses are increasingly more airtight.

We know that vented appliances are subject to back drafting. The National Building Code of



Canada has mandated for years that "spillage resistant" appliances need to be used if there is no control of house depressurization. Exhaust-only ventilation can be used only where the dwelling unit "... contains no solid-fuel burning appliance, no fireplace of other than direct-vented type, and no other fuel-fired space- or water-heating appliance of other than direct-vented or mechanically vented types....". *(NBCC 9.32.3.6.1 (a))*.

The accepted limits are 5 Pascals depressurization if there are naturally vented appliances in the house, and 10 Pascals if there are no spillage-susceptible appliances. Unfortunately, mechanical equipment is not tested or rated for operation under depressurized conditions. Protocols for such tests are only now being developed, without the appliance manufacturers' support.

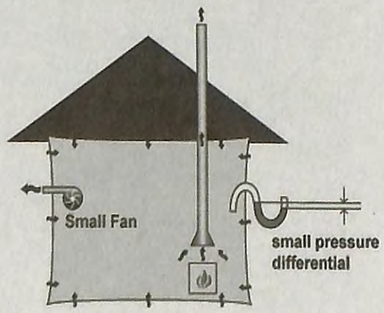
The gas appliance industry in particular does not seem to understand the importance of the issue, and does not seem to be willing to take action. The Gas Appliance Manufacturer's Association (GAMA) has stated that it "does not support the concept of imposing any depressurization spillage test on gas appliances". They seem to be concerned about ongoing research about depressurization limits of spillage resistant appliances because they do not accept that gas appliances should be modified to pass a depressurization test to compensate for "a deficiency in the house ventilation system." In all likelihood, they may need to take responsibility (and liability) for the consequences of using their products at depressurization levels greater than 5 Pascals.

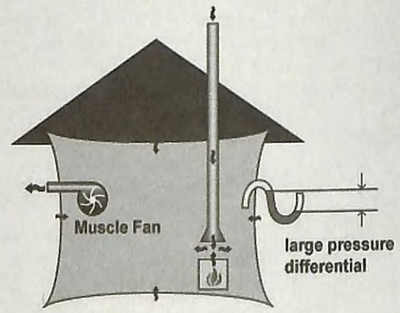
GAMA does recognize that there may be a concern about depressurization, but they suggest that depressurization is not a condition of gas appliance operation or design, but rather a condition external to the appliance. They would like to believe that the root cause of any depressurization is "a failure of the home designer or builder to ensure the home is adequately ventilated or a failure of the installer to assure that the appliance has an adequate supply of air for combustion and ventilation."

In part, GAMA's opposition to setting depressurization limits and testing of equipment may be that it would effectively eliminate naturally vented gas appliances equipped with draft hoods. They seem to ignore the fact that the days of naturally vented combustion appliances are limited not only because of susceptibility to back drafting, but also because of energy efficiency regulations needed to increase the energy efficiency of energy consuming appliances to deal with climate change issues. While the gas industry does not want to assume responsibility for appliances operating at higher levels of house depressurization, they are prepared to sell consumers the more expensive appliances that are now required by energy efficiency regulations.

Although neither the manufacturer nor the installer has any control over the construction of the residence or of the ventilation system provided for it, they need to recognize how new homes are being built today. The environment into which heating appliances are installed is different than it may have been in the past, or still exists in other parts of the world. The equipment used today needs to reflect the changed environment.

Blower door tests have tracked the change in construction practices over the years. The same blower door test approach can be put to good use





The 2000 CMHC study of new houses (***Field Tests of Ventilation Systems Installed to Meet the 1993 OBC and 1995 NBC***), showed that the average clothes dryer in the 49 houses studied had an exhaust flow of cfm (55 L/s) and the largest dryer flow was cfm (85 L/s). The data shows that in 8 of the 49 houses depressurization would exceed 5 Pa solely due to a clothes dryer with an exhaust flow of 55 L/s and in 21 of 49 it would exceed 5 Pa with the airflow of the higher airflow dryer. There are no balanced flow clothes dryers, so these appliances will always contribute to depressurization of the house.

Large capacity kitchen range hoods (e.g. downdraft cooktops and barbecue stove hoods) in many cases may depressurize a house, so they will require their own fan-forced make-up air. Large capacity exhaust devices such as these should be provided with a make-up air option, to make it easier for installers to do a proper installation, although manufacturers don't always make it easy, nor do they provide make-up air kits.

In Vancouver, where we see many large capacity kitchen fans used, especially in homes for the Asian market which have oriental "wok" kitchens (which resemble a scaled-down commercial kitchen) contractors have developed ways to install fan forced make-up air (which needs to be preheated) into the kitchen. It's not always easy or straightforward, but it is necessary.

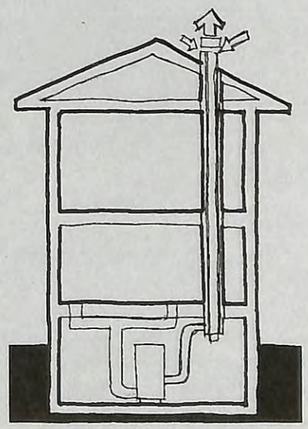
for equipment development. Heating equipment manufacturers could use a similar tool to test and quantify how much leakage is occurring from their heating and venting systems, and more importantly, to determine what levels of depressurization can be sustained by the equipment.

Perhaps nowhere is the potential benefit more widespread than with oil-fired equipment. Odour complaints are becoming increasingly common in homes with oil-fired equipment, especially with the trend towards finished basements that include offices and bedrooms adjacent to the furnace and water heater. In winter, the stack effect means that the basement generally is at a negative pressure relative to the rest of the house, and the amount of depressurization can exceed 5 Pascals, especially in the winter during cold weather. (Readings as high as -15 Pa have been observed in randomly selected homes). If bathroom fans and a dryer in the basement are turned on, the negative pressures increase.

NRCan has supported the development of a test protocol for gas appliances (Solplan Review No. 125). Kerr Heating Products, a leading oil-fired heating appliance manufacturer based in Nova Scotia, was interested in the gas-fired equipment test protocol for testing their oil-fired equipment.

Kerr used a modified version of the test protocol to test their equipment. They just released a report on the work they did to become the first manufacturer to carry out this testing in their own lab facility. Being the first to develop a facility, commission it, test products and analyze the results, Kerr should be in a good market position when it comes to providing oil-fired equipment that minimizes the risk of odour issues.

The test and testing equipment is not expensive – Kerr calculated the total cost to develop the test chamber was less than $12,000 since every manufacturer will already have some of the monitoring and testing equipment. Other manufacturers will surely want to follow suit, so that they can evaluate the performance of their equipment and mitigate any potential odour or other depressurization and spillage related issues.



As would be expected, direct vent oil furnaces and boilers performed much better than the same equipment with other types of venting systems. The results are interesting as they show that there is a considerable range in the performance of each type of system. Minor modifications can be made in the design of the system and the installation practice to significantly improve the performance of products within any particular venting category.

Table 1 shows the range of spillage associated with different equipment and pressure limits. Elements that can have

Equipment Venting Description	Depressurization (Pa)	Spillage (%)
Chimney with barometric damper	5	1 - 6
Chimney without barometric damper	5	1 - 7
Chimney with barometric damper	8	3 - 14
Chimney without barometric damper	8	1 - 7
Flex Vent connected to chimney combustion air from room, no barometric damper	8	1
Flex Vent connected to chimney combustion air from room, no barometric damper	20	8
Flex Vent connected to chimney combustion air from room, no barometric damper	50	21
Direct Vent	50	1 - 7

Table 1. Depresurization test results of a variety of Kerr products.

an impact on the leakage include the vent pipe, the pipe sealing approach, the use of a barometric damper, the burner type, the burner flange, and the way in which the burner is sealed to the furnace or boiler. CSA standards allow a 2% leakage at the heat exchanger and vents in oil burning appliances, and 4% is allowed from the combustion chamber in oil-fired boilers. Kerr's testing evaluated total leakage from the appliance.

Kerr has also indicated their intent to develop vertically direct vented oil heating products. Sidewall direct vented oil heating systems appear to be the best option for minimizing combustion related odour issues. However, some builders are reticent to use sidewall vented appliances because of concerns about potential effects on the surrounding siding, moisture loading on adjoining surfaces, and potential odour and moisture complaints from neighbors. Vertically venting the combustion products is one way to minimize the problems.

In order for manufacturers to commit to manufacture equipment such as vertical direct-vent oil heating systems, they need to know that there will be a reasonable market for such equipment. The Yukon Housing Corporation is one organization that is very interested in such systems, especially since in their region oil and wood are the principal fuels available. But there are other regions where oil still has a significant market share.

If you are a potential buyer or user of such systems, you can register your interest on the Yukon Housing Corporation web site. The Yukon Housing Corporation will collate results and provide them to oil heating product manufacturers. If builders don't ask for improved, vertical direct vent oil equipment, manufacturers won't build it.

Some manufacturers of fuel-fired equipment do recognize that there is a sales advantage to products that can deal with higher house depressurization. Who knows, if the oil industry starts manufacturing tested, spillage resistant, energy efficient equipment, the gas appliance manufacturers may be forced to follow with gas appliances. In some regions builders are already moving away from natural draft gas furnaces (due to efficiency regulations) or natural draft gas water heaters (due to depressurization issues) without any big builder or consumer backlash.

If the gas industry is unwilling or unable to modify the design of their equipment so that it can be installed in houses experiencing depressurization greater than 5 Pa, then we may need to rethink mechanical systems for new homes, since we know they experience higher depressurization conditions, and spillage of combustion products into the home is a health and safety concern. Use of appliances that are not spillage resistant would be putting occupants at risk, and make builders liable for creating unsafe conditions. ☼

Anyone with questions about installing oil systems so that they are more likely to withstand depressurization can contact Bill Spencer at Kerr regarding their work on spillage testing of oil fired appliances. He can be reached at 902-893-4712 or by email at wspencer@kerrheating.com

If you are a potential buyer or user of vertical direct vent systems for oil-fired appliances, or wish to pursue this issue, you can contact Juergen Korn at the Yukon Housing Corporation: www.housing.yk.ca

Technical Research Committee News

Building Envelope Inspections

Building envelope problems are not unique to the Vancouver,Victoria or coastal Nova Scotia areas. As a result of a growing number of complaints about leaking building envelopes, the City of Calgary will be starting a pilot project to conduct spot check inspections of building envelopes during construction. The intent of the project will be to improve the building envelope construction by educating builders about any deficiencies noted.

New Plastic Venting Requirements For Gas Appliances

Representatives of provincial and territorial regulators of fuel safety form the interprovincial gas advisory committee. They have received enough reports of cracked or broken plastic vent pipes and fittings that new requirements were needed. Primarily, the concern appears to be with lower efficiency power vented domestic hot water heaters.

During summer 2006 a new requirement was added to the CSA B-149 Natural Gas And Propane Installation Code. A 2007 Supplement to CSA B-149.1 will be published Jan. 1, 2007. The supplement includes two clauses that apply to plastic vent systems:

8.9.5 Venting systems, or total vent run if less than 3 ft (900 mm), that employ plastic vents shall be installed such that the first 3 ft (900 mm) from the appliance flue outlet is readily accessible for visual inspection.

8.9.6 Vents constructed using plastic piping shall be certified to ULC S636 (Underwriters' Laboratories of Canada Standard for Type BH Gas Venting Systems).

The key materials used up to now for plastic venting have been ABS, PVC and CPVC. These plastic piping materials were originally certified and manufactured for plumbing use. As it happened, they work well and are readily available so they have also been used for venting gas-fired appliances. The new requirement for certified vent piping will be implemented in each jurisdiction according to local legislative procedures.

At this time, there in no certified product on the market that meets the new standard. However, one manufacturer has indicated that they will have their product certified for venting use in early 2007. Their product line will likely include PVC and CPVC material, but not ABS.

If there is certified vent product available when the provincial/territorial authorities implement the code changes, builders may see little impact from the changes. Installers who are familiar with PVC and CPVC products should have no difficulty using certified components. The two main differences that are expected are that ABS may not be certified for venting use and certified PVC and CPVC venting systems will have markings indicating certification for vent use.

The requirement that the first three feet of vent be readily accessible for visual inspection is of more concern for existing installations within finished rooms. When the appliances have to be replaced, access to the first three feet of vent will be an issue. Even in new construction this may be a concern, as often space is at a premium.

Furnace Minimum Efficiency Requirements

NRCan has indicated that they intend to raise the minimum efficiency requirement for gas-fired furnaces from the existing 78% AFUE to at least 90%. While the timeline is not clear, it is meant to be implemented sometime in 2008. Some provinces have already introduced such standards. Since January 2006 Ontario has required that residential buildings use furnaces with AFUE values of 90% for natural gas and propane furnaces. BC will require these effective Jan. 1, 2008.

Canadian Home Builders' Association

The Technical Research Committee (TRC) is the industry's forum for the exchange of information on research and development in the housing sector.

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Building Code Update

The publication of the new edition of the National Building Code has meant an update of provincial regulations. Some provinces adopt the NBC substantially unchanged; others make some local changes and additions.

Ontario

Ontario is one jurisdiction that has a number of changes from the NBC. The 2006 Ontario Building Code has been published. Significant changes include:

- ☛Increases in the energy efficiency requirements for buildings;
- ☛New accessibility requirements for buildings;
- ☛More flexibility in the design and construction of small care homes; and
- ☛Updating/simplifying the requirements for small buildings, including houses.

Most of the new code requirements will come into force on Dec 31, 2006. The transition period is intended to give building officials, builders, designers and product manufacturers time to become familiar with the objective-based format and the new technical provisions.

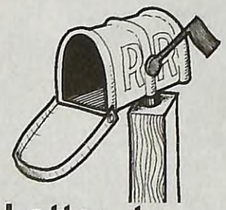
Energy efficiency changes will be phased in. Effective Dec. 31, 2008, the Code will require that new houses be constructed with near-full-height basement insulation. As of Dec. 31, 2011 the Ontario Building Code will require new houses to meet standards that are substantially in accordance with an EnerGuide 80 rating and also require that new non-residential and larger residential buildings meet standards that are substantially in accordance with energy efficiency levels that are 25% higher than the Model National Energy Code for Buildings.

Nova Scotia

2005 NBC was adopted in Nova Scotia on Sept. 1, 2006 with the publication of the 2006 Nova Scotia Building Code regulations.

BC Building Code

The 2006 BC Building Code comes into force Dec. 15, 2006. This edition has some changes from the 2005 NBC. The Home Owners' Protection Office has prepared a Builder Insight Bulletin (#2) which highlights changes to Part 9. Copies of the bulletin can be downloaded from the HPO website: *hpo.bc.ca* or from the BC Building Policy Branch: *www.housing.gov.bc.ca/housing/code*



Letter to the Editor

Re: Rain Screen Walls, (Solplan Review No. 130, September 2006)

Your rain screen article has a slight numerical error about the date when the first rain screen wall was invented. You stated that the rain screen principle was first introduced in 1946.

I'd like to point a quote from the Roman architect Vitruvius active in the first century BC: *"But if a wall is liable to continual moisture, another thin wall should be carried up inside it, as far within as the case will admit; and between the two walls a cavity is to be left...with openings for air. At the upper part also, openings must be left, for if the damp does not evaporate through these holes, it will extend to the new work."*

Vitrivius was the author of De architectura, known today as The Ten Books of Architecture, a treatise on architecture. It is the only significant book on architecture from classical antiquity that has survived. It should also be noted that Vitruvius had a much wider scope than modern architects. Roman architects practiced a wide variety of disciplines; in modern terms, they could be described as being engineers, architects, landscape architects, artists, and craftsmen combined.

Rob Dumont,
Saskatoon.

Thanks for the reminder. We disregard history at our peril. We forget that true innovations are a process of evolution, building on previous knowledge. This is especially true in the building industry.

Over the centuries builders evolved construction practices by trial and error. Knowledge was passed on hands-on from generation to generation. The academic documentation and analysis we do today is recent. We are only now starting to understand why some construction details work. But just because we may not be able to explain it, or are just discovering why some things work, doesn't mean that someone else hasn't thought of it in the past. Ed.

Air Barriers vs Vapour Barriers

There is a big misunderstanding, still, about the difference between an air barrier and a vapour barrier. In part, this has happened because in the past twenty-five years we have changed the way we build houses. We have become accustomed to using polyethylene to provide both an air barrier and a vapour barrier.

Building science tells us that to build a house properly it must be built airtight, since the air leaking out of the house carries a large amount of moisture with it. The moisture will condense on cold surfaces where it can lead to structural deterioration if the materials stay wet. It is air leakage that is the cause of most moisture problems. Stop air leaks and you eliminate most moisture problems due to air leakage.

Air leakage is a function of openings through the building envelope and an air pressure differential that pushes air through those openings. If you have no holes, air movement is stopped. If there is no pressure differential, you have no air movement.

Moisture also moves by diffusion through materials that are permeable to water vapour. Vapour drive is a function of the vapour pressure differential across both sides of an element. Diffusion is a slow process by which water vapour in the air permeates straight through building materials.

Air leakage can carry as much as a hundred times more water vapour than diffusion. Tests done by the National Research Council showed that airflow through cracks in the building envelope accounts for around 99% of the moisture that moves across a wall compared to 1% that moves by diffusion through permeable materials. For example, 300 millilitres of water can pass through one square metre (10 square feet) of wall in winter by diffusion, but as much as 30 litres of moisture can pass through a 2x2cm (1 inch square) hole in the same period, under the same conditions, by air movement.

The vapour pressure itself is a function of the amount of moisture in the air. It can be determined by knowing the temperature and relative humidity. Generally, it is at a maximum during winter, when we keep the interior warm, while the exterior air is cold and dry. On a winter day, the relative humidity outdoors is often at or near 100%, but that air has very little capacity to hold moisture, so its vapour pressure is small. On the other hand, the indoor temperature is warm, and even at a low interior relative humidity, the interior vapour pressure is higher so the vapour drive is outward.

In Canadian climate conditions the direction of the vapour drive is outward. However, on occasions, the vapour drive can reverse. For example, after a rain storm the exterior wall will be wet, while the backside of the exterior cladding will be drier, so when the sun heats up the wall, the exterior surface will be warmer, and the vapour drive is into the wall. This is referred to as a reverse vapour drive.

A common misconception many have is that walls need to "breathe". It is important to realize that the only things that breathe are living things, such as plants, animals and humans. Insulation or construction assemblies do not "breathe". Rather, it refers to the ability of the assembly to allow water vapour to diffuse through it.

However, the moisture is transported from the warm side to the cold side primarily by air leakage. For air to enter a wall cavity through cracks in the inside wall structure, there must first be an exit for the same air. Thus we want to build houses as airtight as possible. While vapour diffusion must be considered, it is less critical for building performance than the airtightness of the building envelope. If the wall is airtight, little water vapour will go through the wall.

We can use a variety of materials to provide airtightness. One approach to improve the thermal envelope of a house and provide an airtight envelope at the same time is to sheath the house with rigid insulation, such as extruded polystyrene. Insulating sheathing reduces thermal bridging through the framing and provides a more even temperature across the exterior wall. However, use of extruded polystyrene insulation, which has a low permeability, generates concerns about creating a "double vapour barrier".

There is a misconception that water vapour will become trapped between the vapour barrier on the warm side of the wall and a low permeance sheathing like extruded polystyrene insulation on the cold side. The thinking is that moisture will be trapped and will cause the studs to rot and the building to decay.

Material *(Each of these can be used as a vapour barrier)*	Water Vapour Permeance ng/(Pa-s-m²)
Polyethylene plastic sheet, 6 mil	1.6 - 5.8
Glass and metal	negligible
Aluminum foil	0
Kraft paper *(vapor permeance changes depending on the specific relative humidity)*	17
Glazed ceramic tile	6 - 9
Vapour barrier paint	26-30
Styrofoam	23-92
Spray-in-place polyurethane (closed cell, 2 pound) 25 mm thick	<60
6.4mm (1/4") plywood plywood	23 - 74
OSB 11mm (7/16") oriented strand board (OSB)	44
25mm (1") foil-faced urethane	Negligible
MemBrain™ Vapor Retarder (2-mil thick Nylon)	<57 @60% RH (*permeability increases at higher humidities)*
The following do not meet criteria for a vapour barrier	
Breather type sheathing membrane	170 - 1400
"30" minute sheating paper	1170
11mm (7/16") fibreboard sheathing	772 - 2465
Spun bonded polyolefin film	3646
Gypsum drywall unfinished	2860

"The function of a vapor barrier is to control water vapour diffusion to reduce the occurrence or intensity of condensation. . . . If a small crack or perforation occurs in the vapor barrier, its performance is reduced . . . and can usually be accepted in practice. . . building codes require a low permeance layer (under 60 ng/Pa/s/m2 or 1 US perm) on the warm side of the enclosure. The choice of 1 perm as the definition of a vapor barrier is essentially arbitrary and traditional and in many situations such a low level of vapor permeance is not required in the interior."

*from **Building Science for Building Enclosures**, by John Straube and Eric Burnett, Building Science Press.*

Causes of Wood Rot

For wood rot to occur in wood stud walls, four conditions must exist:
1. Temperatures greater than 4°C (40°F).
   [Optimum temperature 27°C (81°F)].
2. Oxygen.
3. Presence of appropriate fungi spores.
4. Wood moisture content between 25-32%.

To get all these conditions at any one time is extremely rare. For example, in the summer, when the cavity temperature could exceed 27°C (81°F), this heat will dry any moisture in the cavity below the minimum required (25%) for wood rot.

Condensation occurs when humid air drawn from the inside by air leakage and diffusion meets a cold surface in the wall cavity. Water vapour carried by warm moist inside air will not condense in the wall cavity if the cavity temperatures are warm enough. Without an insulating sheathing, the stud/wall sheathing interface is colder, increasing the likelihood of condensation when air exfiltration occurs. An exterior insulating sheathing warms the wall framing, moving the dewpoint away from the stud cavity towards the colder outside. Thus the inside surface of the sheathing, the first condensing surface, stays warmer.

Styrofoam™ insulation is a low permeance foam sheathing 51 ng/Pa-m² (0.9perms), not an impermeable one. Any moisture that might permeate through the air and vapour barriers will move through the exterior Styrofoam insulation sheathing.

Styrofoam™ insulation has been used for more than 25 years as insulating sheathing in Canada. Dow estimates that more than 1 million homes in North American have been sheathed using Styrofoam insulation products with no condensation problems attributed to the insulation. ☼

Moisture Control Handbook Errata

Joe Lstiburek, building science guru and author of ***The Moisture Control Handbook***, published in 1993, has issued an errata notice on his web site. He notes "In the past decade several things have become obvious to me … the most significant is the role of polyethylene on retarding the drying of building assemblies. I have come to conclude that polyethylene is really a "drying retarder" and should be avoided. … Polyethylene should not be installed on the interior of any assembly – with the exception of above grade walls and ceilings in locations with 4400 heating degree days (°C) or greater. Vinyl wall coverings and epoxy paints or any low perm interior finish should have the same use restriction as polyethylene.

www.buildingscience.com

Radon
What Builders Need to Know

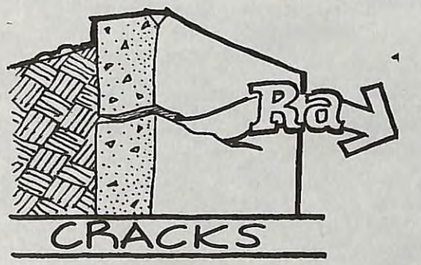
We reported in Solplan Review No. 129 (July 2006) about changes to Canada's Radon Guidelines. Here we present some background, and what builders need to know about how they need to deal with the guidelines.

Radon is one of those naturally occurring environmental contaminants that are present everywhere. Recognition of the potential problem and good building practice can minimize adverse effects.

Radon is a colourless and odourless radioactive gas formed by the natural decay of radium. It is present in soil, rock and ground water in varying concentrations in all areas of Canada.

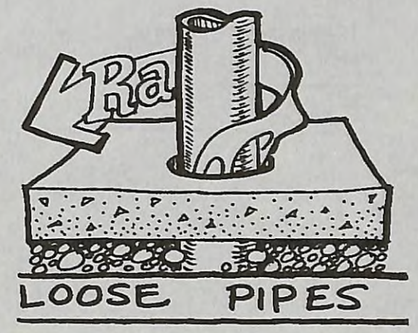
Radium is present in all stone material, but mostly in alum shale and certain granites, as well as some clay soils. As the amount of radon is related to the subsoil conditions, levels can vary widely from region to region and even within a neighbourhood. Since radium is found naturally in many soils, it is impossible to avoid it. However, depending on the local geology, high concentrations of radon can build up in poorly ventilated spaces.

Radon gas enters buildings from the soils on which they are constructed by the way of cracks and other openings in the foundation. In some cases, radon can also be introduced by the water supply, especially when the water source is a well. Small quantities can be released by building materials such as stone, brick, concrete and plaster. Because radon is heavier than air and normally enters buildings from the surrounding soil, concentration of the gas is usually highest in the basement.



The most common test for radon is the use of a charcoal canister that is placed in the home, ideally during cold weather, for two to seven days. The canister is then sent to a laboratory for analysis. The cost is typically about $50.

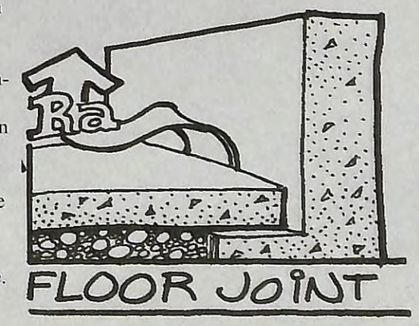
How Serious is Radon? What are Safe Radon Levels?



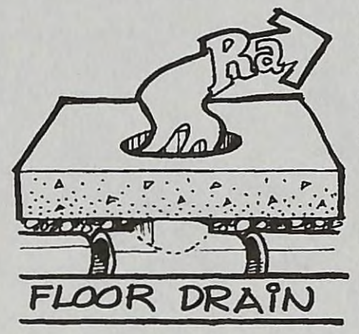
As with other radioactive materials, 'acceptable' levels of the materials have been established but the full implications of exposure are not known with any certainty. Naturally occurring background levels of radon in the open air are low, and a poor indicator of potentially harmful levels inside a building, where in some situations, a high concentration can build up.

The major concern about the health effects of exposure to radon is not the radon gas itself, which has low radioactive emissions. However, when radon breaks down, it decays into solid radon 'daughters' which decay rapidly and give off significant radioactivity in their short life. The radon daughters attach themselves to particles in the air, such as dust and smoke or other solid items they come in contact with. The radiation emitted is capable in the long run of causing lung cancer. The risk is determined by the concentration of the radioactive radon daughters.

Most research in this field has been concerned with occupational conditions in mining operations, where dust is present in high levels and where radon concentrations are much higher than are likely to be encountered in a home. Recent North American and European studies have found that there is a lung cancer risk at much lower levels than was the case in the past.



Radon gas concentrations are relatively easy to measure. The units of measurement



of radioactivity are Becquerels (Bq). Internationally, most countries have now established acceptable rates at 200 Bq/m³. Although there is a measurable risk of lung cancer at rates as low as 100 Bq/m³, a level of 200 Bq/m³ is considered the appropriate level. Current Canadian standards, at 800 Bq/m³, are significantly higher than the international norm.

Health Canada now states that remedial measures should be undertaken in a dwelling whenever the average annual radon concentration exceeds 200 Bq/m3 in the living area. The guidelines also state that the higher the radon concentration, the sooner remedial measures should be undertaken. At levels of 800 Bq/m³ or above, these measures should be completed within one year. When remedial action is taken, the radon level should be reduced to as low a value as practicable.

Where Is Radon Found In Canada?

Higher levels of radon are often found in areas where mine tailings have been used as fill, in buildings built in areas close to uranium mines and in some clay soils. Health Canada is developing a radon potential map of Canada that will be based on a number of surveys that have been done in the past. Many surveys found that in a small but significant minority of houses higher radon concentrations were observed. Although statistically significant geographical differences were observed, variations within a city were often larger than between cities. Unvented basements generally accounted for the highest concentrations.

Winnipeg, Regina, Brandon, Sudbury, Thunder Bay, Fredericton and Sherbrooke as among the hot spots that have previously been identified. The new lower standard may mean that more regions will require serious attention to radon.

How Does One Deal With Radon?

Fortunately, it is relatively easy to deal with radon inside a house. As radon gas is heavier than air, it tends to concentrate in the basement. The main defense is to cut off the radon entering into the house and to dilute and filter the gas that is present in the house. Radon gas entry can be reduced by sealing up all openings and cracks in the basement and observing good air sealing and waterproofing practices by means of a continuous air barrier.

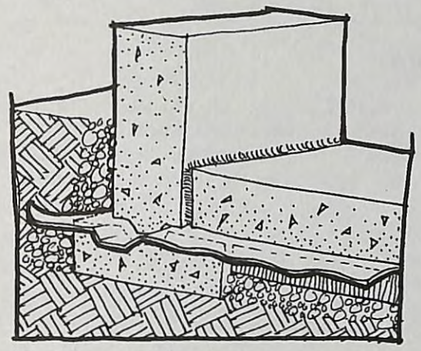
A common approach to dealing with radon in retrofit situations is to seal the basement walls and floor and vent the subsurface soil under the house. Depressurizing the soil and increasing the flow of air beneath the floor can reduce the amount of radon entering the building. This may require the installation of a small sump under the floor that is connected to a sealed pipe and a fan that depressurizes the soil under the basement, thus minimizing any soil gas entry into the house.

After remediation, all homes should be retested in order to verify that the radon concentrations have been reduced sufficiently. This second measurement should be a long-term test for a minimum of three months duration.

For new homes, construction practices should use airtight construction details that will minimize radon entry and will facilitate post-construction radon removal, should this subsequently prove necessary.

☞A common approach used in some areas is to place crushed rock under the foundation of new homes, which will make venting of the subsurface soil easier to retrofit. This can be relatively easy if the floor is known to have a porous gravel base. A solid pipe (such as a 4" diameter PVC pipe) can then be put into the ground below the basement floor, and power vented to the outside by a small fan. There is an added bonus to the "radon rock" under the house: moisture problems through the basement should be minimized as the rock also provides a better drainage layer under the house.

Since radon concentrations are not predictable, and are variable from house to house, the only responsible approach for new home builders is to construct the basement in a fashion that makes the basement retrofit ready should it be needed, especially in regions known to have radon presence. At time of occupancy the house can't be tested so there should not be an expectation for the builder to have installed active radon removal systems. However, an airtight assembly will minimize subsoil air leakage into the house.



Radon gas can be stopped by ensuring there is a continuous membrane under the floor slab (such as 6 mil or heavier poly) that is extended past the wall-slab joint.

☞A water stop joint can be used at the wall-slab joint.

☞Any service penetrations through the foundation wall should be sealed with a good quality flexible masonry caulking.

☞Floor drains should be fitted with a backflow protection damper in the drain or at least a tight fitting cover, especially in existing houses with a floor drain that has no trap in it. If a cover is not appropriate and the drain (with a trap) is seldom used, a light oil film on the water will minimize evaporation of the water in the drain trap.

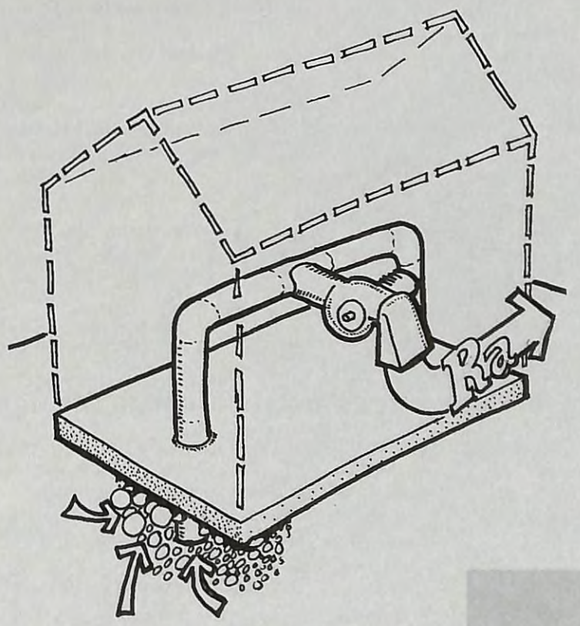
☞Open sumps inside the basement should be avoided. If one is absolutely needed inside the basement, it should be fitted with a tight cover.

☞Within the house, radon concentrations will be reduced by air circulation. Air circulation in the basement is important, for it will move the radon through the house. While this may appear to increase radon levels in the main living areas of the house, it will also reduce radon concentrations in any one area. The forced air movement will bring air that contains radon daughters into contact with many surfaces (ducts, walls, furnishings) so that any radon daughters will tend to adhere to these surfaces and will not be available for inhaling.

☞In a forced air heating system, continuous low speed airflow is important to dilute radon concentration.

Radiant heating systems do not offer the same ease for reducing radon concentrations. In such cases, especially in houses where the basement is not used as living space, a separate air circulation loop should be considered.

It is important to note that mechanical ventilation systems must be designed and installed carefully to ensure that the basement areas are not depressurized, or this will only draw more radon into the house. This is a good reason why basements should be avoided in radon-rich areas.☼



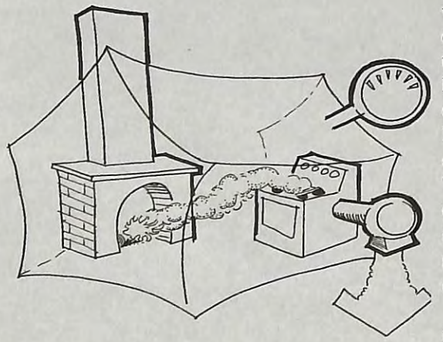
A Lesson in the Importance of Fundamentals

Why you can't forget about the House-As-A-System

The Internet has become a useful communications tool, although you need to be careful how information gleaned is used. Not all information is correct or appropriate for all conditions.

We came across an interesting item on a site for American architects, which discusses green building issues. The story points out the importance of understanding fundamental building principles and how they can potentially compromise the health and safety of occupants when they are not considered. Unfortunately, the author missed the key lesson to be learned from his experience.

The architect described what happened in a major residential renovation that essentially rebuilt half of the structure. Knowing how poorly the original house was constructed, he ensured that the house was sealed and insulated as best as possible, especially in the new portion, especially as they were adding large amounts of glass in the new kitchen. They worked the design and detailing with great care to ensure that they met a high standard of energy efficiency, and focused a lot of effort on details to eliminate air infiltration. They felt they had met every installation requirement that was necessary to maintain energy control.



However, shortly after the owners moved in, the architect began to get calls about the pilot flame on the hot water tanks, which were regularly going out. After investigation, they were able to narrow down the problem to a very simple cause: the new structure was built so airtight that it depressurized the house enough that every time the owner used the high-speed setting on the range hood, the back draft in the venting caused the pilot flame to be blown out. Since the owner had purchased the two hot water tanks shortly before the project started, they had not considered replacing them with new higher efficiency spark ignition sealed units.

Evidently, the architect and his team did not understand that there are depressurization limits with naturally vented combustion appliances, and the importance of ensuring that there was adequate make-up air for the new high capacity range hood. Regrettably, they missed the fundamental lesson that a *house is a system* and that the interaction of mechanical equipment with the rest of the building envelope cannot be ignored. Indoor air quality will suffer, interior moisture is contained, and unusual things can happen - such as pilot lights going out.

Instead they concluded the problem was that a completely airtight structure is not desirable.

In fact, an airtight structure is not only desirable, but necessary – BUT you also need to realize that appropriate ventilation is needed for occupants and ensure that proper exhaust and make-up air is provided where it is needed for specific equipment. A ventilation system for the home's occupants will not solve the problem of inadequate make-up air for exhaust appliances.☼

Hidden Infrastructure Costs of Climate Change

Some people, especially in the oil patch and in the current Canadian government are skeptical about the idea of climate change and its impact on the earth despite the overwhelming scientific evidence. This skepticism may largely be a denial of reality.

The insurance industry, for one, has to monitor a wide range of issues that may impact their business. They have accepted the scientific evidence, and are rewriting their policies so that they are not paying out for damages incurred due to climatic changes.

A recent study done at the University of BC should be a heads up for the development industry. It points out that assumptions used by civil engineers for sizing urban infrastructure, such as storm sewers, may be out of date because the climatic changes mean that peak storm loads are much greater than was the case in the past. This means that the rule books may have to be rewritten to take into account the bigger peak loads. It will mean higher costs for the development industry for new developments or redevelopment of older areas.

You Asked Us:

About Hydronic Baseboard Heating

I've got a beef. There is much attention being paid to radiant floor heat these days, but no one seems to talk about good old hot water baseboard heaters. They're relatively inexpensive, easy to retrofit, and easy to zone (thermostatic zone valves in each room even!) In a low air leakage house I'll bet the comfort would be very good. What do you think?

DB, Oregon

The heat loss in a well-insulated house is small, so little heat is needed. In a radiant heating system in-floor piping is used to circulate warm water thus heating the surfaces, raising the mean radiant temperature of the interior surfaces. In-floor radiant heat provides very comfortable conditions on ceramic tile floors, especially if the residents walk in their stocking feet, rather than shoes. Most commonly, in-floor pipes will be placed in a 1½" thick concrete topping that acts as a thermal mass. Sometimes the pipes are attached below the wood subfloor, at which time the insulating effect of the floor assembly and finishes needs to be considered.

The major challenge is that in-floor radiant systems respond slowly to rapid changes in heating needs. Depending on the quantity of thermal mass, it may take longer to raise the temperature, whether or not concrete thermal mass is used. This can be a special concern in fall and spring, when there can be large outdoor temperature swings, and in mild climates. If there are significant direct solar gains into the house and inadequate thermal mass, it can also be a source of discomfort.

The slow response is especially noticeable when there is a need to reduce heat, as can happen on sunny days when the solar gains can raise the indoor air temperature quickly.

You raise a good point about hydronic baseboards as an alternative to in-floor radiant. Baseboard hydronic convectors have been used for years. They are more responsive to temperature swings, and as you indicate, are easier to use in retrofit installations. However, baseboard systems, like electric baseboard heaters, are surface mounted, and must have a clearance around them as they distribute heat by convective air flows. Baseboard and furniture placement must be carefully considered, as an obstructed baseboard will compromise heat distribution.

One other thing that needs to be considered is the operating temperature of the water. In baseboard systems the water is typically hotter than in in-floor radiant systems – 160° to 190°F (71° - 87°C) compared to in-floor radiant systems which must use water no hotter than about 120 - 130°F (48° - 54°C). The cooler water temperatures are needed for in-floor radant systems because the floor surface temperature cannot exceed a surface temperature of 85°F (29°C), which is the limit a human body can tolerate on an ongoing basis. Thus water heaters that might be used for in-floor radiant systems may not be adequate for hydronic baseboards.

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Energy Answers

Rob Dumont

Do any companies make a meter or readout that will allow you to instantaneously determine how much electricity you are using in your house?

There are several companies that now market such a device.

Blueline Innovation, a Canadian company, has a Powercost Monitor. A picture of the portable readout device is shown in Figure 1. The sending unit is shown in Figure 2. Once attached to your electric meter, the sending unit counts how fast the aluminum disc inside the meter rotates. It then sends a wireless signal that goes to the readout device that can be placed anywhere within 30 meters of the electric meter.

Figure 1. Powercost Monitor Readout

Figure 2. External Clip-on Device for the Powercost Monitor that attaches to an electrical meter

You don't need an electrician to install the device, as it is mounted on the outside of the electric meter and does not touch or interfere with any of the components inside the meter. The readout gives values in either kilowatts or $/hour. It will also measure the cumulative consumption in kilowatt-hours. A neat bonus is that the unit will also tell you the outdoor temperature.

One disadvantage of the Powercost Monitor is that its resolution is not very good at low electrical consumption values. The lowest value it can read is 0.1 kilowatt. Thus it is not useful for determining those nagging loads that exist in most houses caused by small electrical usage even though the device (TV, VCR, DVD player, etc) is nominally off.

A company from the U.S. produces The Energy Detective (TED). It's more complicated (and dangerous) to install, and should only be installed by an electrician. It consists of two electrical current clamps and a sending unit that fits inside the main breaker panel for the house, and a plug-in readout device that can be located anywhere in the house on the same leg of the electrical panel as the sending unit. A picture of the readout device is shown in Figure 3.

The resolution of the TED is 10 watts, considerably better than the 100-watt value for the Powercost Monitor. One other advantage of the TED is that it can be used to sub-meter loads. An electrician can hook it up to any load such as a dryer or a stove and sub-meter these loads.

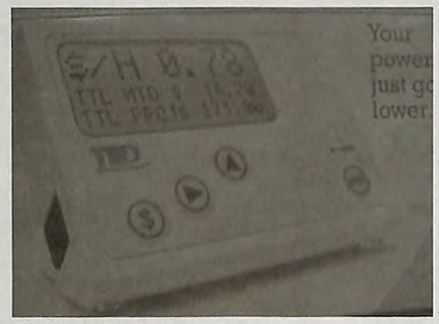

Figure 3. Readout Device for the TED

Do these devices help at reducing power consumption?

"What gets measured, gets managed." A recent paper (http://www.fsec.ucf.edu/bldg/pubs/using_energy/index.htm) has a review of the effectiveness of the devices. According to the authors, "Existing studies show that providing direct instantaneous feedback on household electrical demand can reduce energy consumption by 10-15%."

How much do they cost?

I have bought both the above devices. The Powercost Monitor was $188 Canadian and the TED was about the same. I ordered both over the Internet.

Are there alternative ways to determine how much electrical power you are using?

A little known technique is the following. Almost all utility supplied electrical meters can be used to determine the instantaneous power. All you need is a stopwatch and some patience. On the front of the meter there is a Kh value which is the meter calibration constant (See Figure 4.). This value, which usually has a numerical value of either 3.6 or 7.2 on most residential meters, is equal to the number of watt-hours per revolution of the big aluminum disc inside the meter. Thus if the disc takes 10 seconds to make one revolution, the amount of power being used is equal to 1 revolution/10 seconds x 3.6 watt-hours/revolution x 3600 seconds/ hour or 1296 watts. If it takes only 1 second to go one revolution, the power consumption has increased to 12,960 watts.

One disadvantage of this technique is that it can take a long time to determine the wattage if the power consumption is low. For instance, if the house is only using 25 watts of power, it will take 518 seconds or about 8.6 minutes to get one revolution of the meter. If you are patient, however, the technique will work for you.

Another approach is to use the small dial on the kilowatt hour meter. One revolution of the small dial (Figure 2) on the meter is one kilowatt hour. With care, you can read the meter to about 1/100 of a kilowatt hour.

Is it cost-effective to use one of these devices?

With projected energy savings of about 10-15%, the devices can be very cost effective. For under $200 you can buy the Powercost Monitor, and on a typical house it will likely save you about $100 or more per year. What other safe investments can offer you a 50% annual rate of return? "What gets measured gets managed."

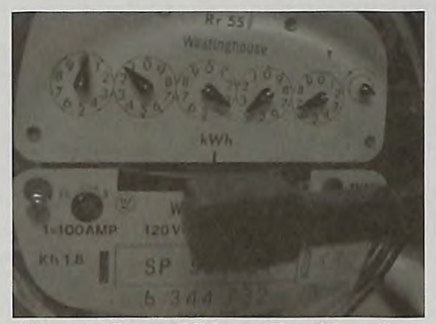

Figure 4.. Electrical Kilowatt Hour Meter. Note the Kh value of 1.8 in the lower left corner. The aluminum disk that spins is just below the Kh lettering on the meter. The Kh parameter is the number of watt-hours per revolution of the aluminum disk.

Where can I order one of these devices?

Here are the web addresses:
Powercost Monitor
www.bluelineinnovations.com/powercostmonitor.php

The Energy Detective (TED)
www.theenergydetective.com

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NRC·CNRC

Research to Improve the Performance of Stucco

By Phalguni Mukhopadhyaya

It's impossible to drive through a new suburb without noticing the rise in popularity of stucco, or portland cement plaster, as an exterior finish. Relatively inexpensive, durable, and attractive , it makes a fine finishing for a home. Unfortunately, in some cases, wood frame exterior walls with a stucco cladding have failed to perform to design expectations in locations with heavy or sustained rainfall.

Studies show that stucco cladding with low liquid diffusivity and high water vapour permeability can positively influence the overall moisture management capacity of wood frame stucco walls. For this reason, the NRC Institute for Research in Construction (IRC), in cooperation with Canada Mortgage and Housing Corporation (CMHC), is working on a project to improve the performance of stucco cladding by modifying existing mix designs and testing new materials.

NRC-IRC researchers have worked to develop a portland cement stucco material that would limit liquid water entry on its exterior surface and at the same time allow water vapour to transmit through it. For the purposes of the project, they considered the stucco as an isolated component of the exterior wall system: they did not investigate system performance of the wall assembly with stucco as a cladding. The effects of imperfections, defects and anomalies typically found in exterior wall systems also fell outside the scope of investigation.

For comparative purposes, Phase I of the research established the basic moisture transport properties of stucco mixtures presently used in Canadian housing construction (i.e. base case stucco materials). Phase II investigated the performance of modified stucco materials. The four novel stucco materials included:

1. Hydrophobic coating on exterior surface

The first trial used a hydrophobic (water repelling) coating (Triethoxy-N-Octylsilane) applied directly to the exterior face of one of the base case stuccos. Although the hydrophobic coating was likely to reduce liquid water entry (low water absorption coefficient), it was known that it could also reduce the water vapour transmission rate.

2. Hydrophobic aggregate

The second mix used hydrophobic aggregates in the likelihood that they would reduce the water absorption capacity of the stucco material without reducing its ability to transport water vapour through it.

3. Aggregates coated with hydrophobic chemical

The third trial mix used graded dry natural sand that was soaked in a hydrophobic liquid and then dried. This treated sand was then used as hydrophobic aggregate for the stucco mix design.

4. Zinc stearate admixture

The fourth and last mix used zinc stearate as an admixture. When added to plaster, zinc stearate is known to decrease the liquid water transport properties and water vapour absorption capacity of plaster. It also changes water vapour permeability. In this study, zinc stearate was used as an admixture.

The results of these limited tests showed that the hydrophobic coating reduced the water absorption but also resulted in low water vapour permeability. The stucco mix that contained the hydrophobic aggregate had the highest water absorption coefficient among the modified stucco materials.

The trial stucco mix using aggregates coated with hydrophobic chemical and the mix using zinc stearate as an admixture showed promising results. Both had relatively low water absorption coefficients combined with high water vapour permeability compared to the common stucco materials used in Canada.

This pilot project, which involved studies on small-scale specimens, investigated the possibility of improving the moisture management performance of stucco materials. The research showed that it is possible to alter stucco mix designs to reduce the liquid water absorption coefficient of the stucco material without reducing water vapour permeability. Based on these positive results, further work is required to refine the stucco mixtures and validate the utility of these results through full-scale system investigation and numerical modelling. NRC-IRC has initiated a new research project to examine all these issues.☼

Dr. Phalguni Mukhopadhyaya is a research officer in the Building Envelope and Structure program of NRC-IRC.

If you have questions on this project, or if you are interested in participating as an industry partner, please contact Dr. Phalguni Mukhopadhyaya at (613) 993-9600, or e-mail: phalguni.mukhopadhyaya@nrc-cnrc.gc.ca.

CMHC Net Zero Energy Healthy Housing (NZEHH) Update

Net Zero Energy homes integrate high performance, energy efficient passive solar design and commercially available on-site renewable energy systems such as solar water heating, electricity and ground source heat. They are designed to produce as much energy annually as they consume. Connected to the electricity grid, these homes draw power only as needed and can feed excess power back into the system.

Net Zero Energy Healthy Housing incorporates the principles of occupant health and comfort, affordability, resource conservation and reduced environmental impact. These significantly reduce greenhouse gas emissions and minimize the detrimental environmental impacts of housing on water, land and air.

More than 75 entries were received by CMHC for phase 1 of their Net Zero Energy initiative. As part of phase I, builder and developer teams were invited to submit their visions for a project that addresses the NZEHH objectives. The successful shortlist of entrants is presented here. This is the first of three distinct phases associated with this initiative.

Twenty teams have been selected by CMHC's NZEHH initiative to proceed to the second phase to develop and submit a detailed design for their demonstration projects in January 2007. From these, a shortlist will be invited to continue and build their proposed project, which will then be on display and monitored. Results will be made known to consumers and industry.

There is no model for NZEHH but commonly it includes:

- Climate-specific design
- Energy and resource-efficient construction
- Passive solar heating and cooling
- Natural daylighting
- Energy-efficient appliances and lighting
- Renewable energy systems such as photovoltaics, solar thermal and ground source heat
- Water conservation and re-use
- Land and natural habitat conservation
- Sustainable community design and green infrastructure practices

- Falls Brook Centre; Falls Brook Centre Demonstration Neighbourhood, Knowlesville, New Brunswick
- Alouette Homes; Alouette Home NZEHH Initiative, Eastman, Québec
- Montréal Zero; Hudson, Québec
- Développements EcoCité; Abondance Montréal, Montreal, Québec
- L'OEUF / Batir Son Quartier / Coteau Vert; Ateliers D'habitation Saine, Montreal, Québec
- Team Encondo; Project ZED (Zero Energy Dwelling), Callander, Ontario
- The Grand House Co-operative Inc.; The Grand House, Cambridge, Ontario
- Minto Developments Inc.; Manotick, Ontario
- Ampas Architect; The Sustainable Urbanism Initiative, Toronto, Ontario
- The Now House Team; Now House, Toronto, Ontario
- Echo-Logic Land Corporation; Echo Haven Calgary, Alberta
- Habitat Studio & Workshop Ltd.; The Riverdale Net Zero Project, Edmonton, Alberta
- Avalon Master Builder; Avalon's Net Zero Energy Discovery House, Red Deer, Alberta
- The Chess Team; Chess, Red Deer, Albert
- Winnipeg Housing Rehabilitation Corporation (WHRC); Urban Ecology, Winnipeg, Manitoba
- NHIP (Nationwest Innovative Housing Partnership); YIPI! A Net Zero Energy Healthy House (Yellowhead Innovation Park Inc.), North Battleford, Saskatchewan
- ZEKO Design Build; Net Zero North: Yukon Sustainable Housing Initiative, Whitehorse, Yukon
- Quiniscoe Homes Ltd.; Annualized Geo-Solar Home, Invermere, B.C.
- TQ Construction Ltd. & Sustainable Building Centre (SBC), Brantwood, Hanvey House, Vancouver, B.C.
- Dockside Green Ltd.; Dockside Green, Victoria, B.C.

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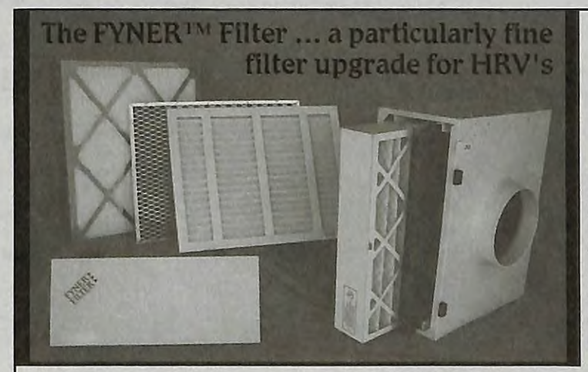

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• horizontal, or
• reverse flow
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• a 1.5 lb. Odour Control Filter, or
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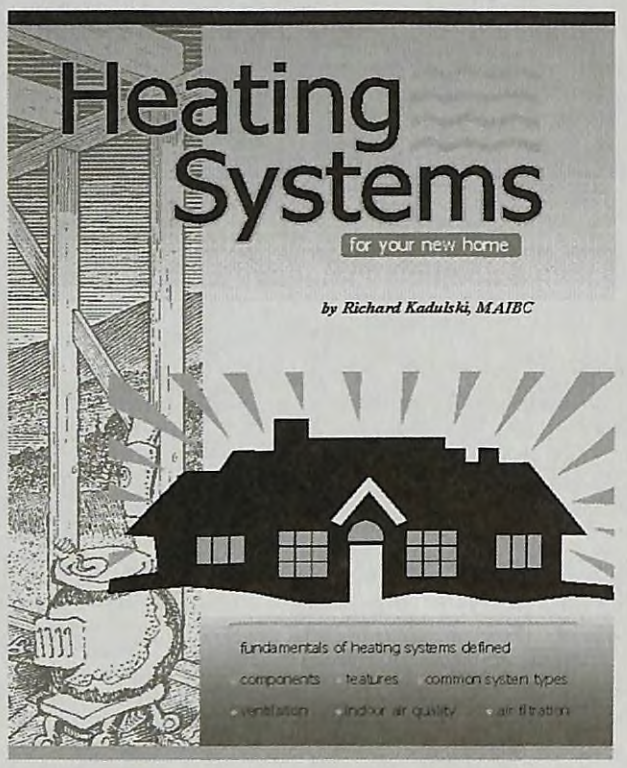

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